ON THE

# EMPLOYMENT OF OXYGEN

AS A

# MEANS OF RESUSCITATION IN ASPHYXIA,

AND OTHERWISE AS A

# REMEDIAL AGENT.

BY


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# ON THE EMPLOYMENT OF OXYGEN, &c.

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The object of the following communication is to recommend the administration of oxygen to persons in a state of asphyxia, as a means of effecting their restoration from that condition, and to point out its value as a remedial agent in other abnormal conditions of the system. In discussing the subject, I propose to consider the following questions :—

1. Is the artificial introduction of a respirable gas into the lungs of an asphyxiated person likely to prove serviceable ?

2. If the maintenance of artificial respiration be advisable, what reasons are there for supposing that oxygen is preferable to common air for this purpose ?

3. What is the best method of preparing oxygen for administration in cases of asphyxia ?

4. What is the best method of administering the gas when prepared ?

In reference to the first of these questions, it may be observed at the outset, that the opinions of medical men are much divided as to the advisability of having recourse to artificial respiration. "Haller, Hunter, Goodwyn, Coleman, Bichat, Kay, Carpenter, and indeed almost every writer on asphyxia, from the time that the chemical changes that take place between the blood and the air in the lungs began to be understood, down to the present day, have insisted on the paramount importance of supplying the blood in the pulmonary vessels with fresh air, in some way or other, as rapidly as possible. On the other hand, the Royal Humane Society, acting under the guidance of the medical members of its committee, namely, Sir B. Brodie, Mr Dalrymple, and Mr Wooley, gentlemen whose names entitle any opinion that may emanate from them to the most serious consideration of the pro-

fession, has somewhat discountenanced the employment of these means, which are but rarely had recourse to in the institution in Hyde Park."*

On a fuller consideration of the objections to the employment of artificial respiration, it appears that they are made partly on the ground of its danger, partly on that of its inutility. As it will be needless to consider the question of danger unless we have settled in the affirmative that of utility, I take up the latter first, reserving the former for discussion under the head of modes of administering the gas.

A general impression appears to prevail among medical men, sanctioned by the tenor of the Royal Humane Society's reports, that cases of asphyxia which can be restored will be recovered without the employment of artificial respiration, and that the latter is never effectual where other methods have failed. It appears that, to a great extent, this opinion is well founded; but it is also true that the cases saved are those of persons who had not been very far gone in asphyxia, and in whom, accordingly, secondary means suffice to effect restoration. "Thus, for instance, in the Report of the Humane Society for 1840, it is stated that 185 cases were brought under the notice of that institution during the preceding year, and that out of these only sixteen were not recovered."† But "it is also stated in that very report, by the very intelligent and humane surgeon of the receiving-house in Hyde Park, that, with one exception, no case had been saved that had been more than four minutes under water."‡ It is only therefore because the great majority of cases in which attempts at restoration are made at all, have not been submerged for more than four minutes, that so many recover by the employment of the hot bath, friction, and stimulants; not because these methods are certain to reach to every case of asphyxia. On the other hand, it would appear that as many as sixteen persons were lost at one place in one year, whose cases were

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* Erichsen on Asphyxia, p. 40. † Op. cit., p. 36. ‡ Ibid.

favourable enough to induce an attempt to be made towards their resuscitation.

It is further affirmed, however, that artificial respiration has been tried in cases which could not be recovered by the ordinary means, without producing any good effect. On this point the opinions of medical men are far from unanimous, nor can a single or even a frequent failure be considered as decisive against the value of the practice. Although, in general, the Royal Humane Society considers it unnecessary to have recourse to artificial respiration, one of the members of its medical committee (Sir B. Brodie) recommends its adoption in those cases of secondary asphyxia in which the patient, after having been revived for a time, gradually appears to sink again into a state of insensibility, being, as Dr Davy expresses it, "poisoned by his own blood;" and another (Mr Wooley) states, that "the practice adopted by him at the receiving-house of the Society is to employ artificial respiration in all those cases in which the respiratory actions are not naturally restored on taking the sufferer out of the water, or on placing him in the hot bath." The fact that artificial respiration is had recourse to at all by the Humane Society may suffice to prove that it cannot be an essentially dangerous practice, and may further be accepted as at least shewing that it is not considered an absolutely useless one.

It is impossible, indeed, that the introduction of air into the lungs should not be serviceable to asphyxiated persons. It is certain, on the other hand, that no case can recover without its entrance into the respiratory organs, and free action on the blood there. The certainty of this, however, does not supply a decision in the affirmative of the much more important practical question, Will it suffice to restore life where other methods of treatment have failed? Nor can the results of the unsystematic trials which have been made on the human subject be considered as settling the question either way.

Mr Erichsen, in his very able Essay on Asphyxia, to which I am indebted for almost all the physiological and medical statements contained in this paper, has pointed out that the problem of the value of artificial respiration will be decided by the answers we can supply to the following questions :—

"1*st*, Can artificial respiration re-establish the circulation through the lungs after it has entirely ceased?

"2*d*, Can it re-excite the contractions of the heart after they have entirely ceased?" (P. 14.)

The former of these questions, it is quite certain, may be answered in the affirmative. Many physiologists have made experiments on the subject, and in general with the same result. Mr Erichsen and Dr Sharpey have recently prosecuted a lengthened inquiry into the matter, and their conclusion, as stated by the former, is, that their experiments clearly prove "the possibility of the re-establishment of the circulation through the lungs after the heart's action has entirely ceased."

In one case, for example, in which, however, the result was not more decisive than in many others, it is stated that "although artificial respiration was not established until 37½ minutes after the ventricles had ceased to contract, yet the blood that had stagnated in the vessels of the lungs, rapidly became oxygenised, and passed in large quantity into the left cavities of the heart."

The second question is much more important than the first, since there can be no doubt that, if we had any means of restoring the heart's action after it had entirely ceased, we should succeed in recovering many cases which are lost at present. Sir B. Brodie, who has made a number of experiments on the subject, is of opinion that the action of the heart cannot be re-excited by inflation of the lungs after it has once ceased. Mr Erichsen found that partial contraction of the heart (viz. of the auricles) after it had ceased to act, might be excited by the insufflation of air; but he never "succeeded in restoring contractions of the ventricles by means of the inflation of the lungs with common air, provided they had fairly ceased to act before artificial respiration was set up;" so that he thinks "we may agree with Sir Benjamin Brodie, that the action of the heart cannot in general be restored by this means after it has once ceased. But, on the other hand, there is never any difficulty in re-exciting the action of this organ, if regular contractions of the ventricles are still continuing, however feebly and slowly." (P. 47.)

All the experiments referred to were made with common air. They were so encouraging that Mr Erichsen was induced to repeat them with oxygen, and the repetition was attended with the most satisfactory results. Nine experiments were tried, and in four of these "it was found that not only after the contractions of the ventricles, but also, in some cases, those of the auricles, had fully and entirely ceased, the action of the lungs could be restored by inflating the lungs with oxygen gas."

Mr Erichsen's estimate of the value of these experiments in relation to the human subject, is expressed as follows: "Judging, then," says he, "from the experiments on animals, the only data that we can safely go upon, I would earnestly impress upon the Humane Society the expediency of giving the inflation of the lungs with oxygen a trial in cases of asphyxia from submersion. I am the more earnest in this entreaty, as this gas has already been found by Dr Babington, Mr Morgan, and by a German chemist, to be of use in asphyxia from the inhalation of carbonic acid." We may, then, I think, consider our first question as answered in the affirmative, and look upon the value of artificial respiration as sufficiently certified to make a trial of it at least worth while, in cases of asphyxia.

The second question, concerning the relative value of air and oxygen as the gas most suitable for introduction into the lungs, has been so far answered already in the discussion of the previous question. I have preferred quoting the conclusion of a practical medical man, as to the ascertained effect of oxygen on the lower animals, and its probable value in restoring from asphyxia the human subject, to recounting the merely theoretical or purely chemical grounds, on which a preference would be given to that gas over common air. It would have been easy to supply these; and three may be mentioned.

1*st*, Oxygen will reach the blood more rapidly than common air. We know that when gases exchange places with each other, the replacing volumes are different according to the specific gravity of the gases, a certain volume of a heavy gas being exchanged for a larger volume of a light one. In maintaining artificial respiration accordingly, whatever gas

we throw into the lungs must exchange places with the nitrogen and carbonic acid leaving them ; and as the latter is a heavy gas, the heavier the gas we cause to replace it the better, since we shall have thereby a larger volume of carbonic acid thrown out, than when the entering gas is a light one. The worst gas we could employ for this purpose would be hydrogen, as it is twenty-two times lighter than carbonic acid ; the best would be a gas heavier than carbonic acid ; but all the respirable gases are much lighter, and we must content ourselves, accordingly, with selecting the heaviest of them otherwise admissible.* In so far, then, as oxygen s heavier than air, it is, *cæteris paribus*, preferable as the gas to be thrown into the lungs of an asphyxiated person. The difference in favour of oxygen is not very great, its specific gravity being 1102·6, that of air 1000. I have referred to this point, however, as the advantage has been supposed to be the other way.

*2dly*, Oxygen displaces carbonic acid from the blood more rapidly than air can do. This results from its greater solubility in that fluid, which enables it after reaching the blood to dissolve more speedily in it than air does, and, therefore, to expel more swiftly from it the carbonic acid previously in solution.

*3dly*, The power of red or arterialised blood to recommence the circulation at the lungs, and to re-excite the action of the heart, after they have entirely ceased, is closely connected with, if not entirely dependent on, the quantity of oxygen dissolved in it. The power of any gas to arterialise blood will, therefore, be proportionate to the quantity of oxygen present in it ; and as atmospheric air contains only $\frac{1}{5}$ of its volume of oxygen, the latter must be four times more rapid and effectual than air in oxygenating the blood.

The third question proposed for consideration was, " What is the best method of preparing oxygen for administration in cases of asphyxia ?"

Hitherto the processes for preparing oxygen have been too tedious and troublesome to offer the least encouragement

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* If the specific gravity were the only point requiring attention, Nitrous Oxide would rank above Oxygen, its density being 1527.

to have recourse to them as extemporaneous methods of preparing the gas; and the objections to any attempt to keep supplies of oxygen ready made, are too manifold to call for special notice.*

Within the last two years, however, a modification of the well-known process for preparing oxygen from chlorate of potass has been introduced, which appears to bring oxygen quite within reach of the medical man as a therapeutic agent. It consists in mixing the chlorate with a tenth of its weight of the black oxide of manganese, the black oxide of copper, or of certain other oxides, and applying heat, as is done in the ordinary process with the unmixed chlorate. The chlorate itself does not yield oxygen till it is fused; and although it gives it off with considerable rapidity at first, at a subsequent stage of the process it becomes thick and pasty from the formation of hyperchlorate of potass, and the temperature must be raised to nearly that of a red heat to secure the evolution of the remaining oxygen. During this last stage, moreover, the salt cakes and conducts heat very badly; and, from all these causes, the evolution of oxygen is extremely fitful and irregular. The extraordinary effect of the simple addition of a little metallic oxide in preventing all this, and quickening the evolution of oxygen, can only be appreciated by those who have witnessed it. But it may give those who have not some conception of the difference it occasions, if I mention that, with a glass retort, heated by a single spirit-lamp, containing the chlorate of potass mixed with a tenth part of its weight of oxide of manganese, it is easy to obtain 200 cubic inches of oxygen within four minutes of the first

* Mr Erichsen has stated that "there would be no difficulty in keeping a supply of oxygen at the larger receiving-houses of the Humane Society, in a zinc gasometer capable of holding sixty to eighty gallons, which might be filled when necessary at a most trifling cost; the gas prepared from the peroxide of manganese being quite pure enough for the purpose in question." (P. 54.) It is manifest, however, that great difficulties would attend any attempt to keep gasholders of the dimensions proposed in working order; and their unwieldiness would totally prevent their removal from one apartment to another, so as to suit the exigences of medical practice.

application of the flame. The gas begins to come off in a few seconds after the light is applied, and literally gushes in a full stream, till the whole is evolved. The metallic oxide suffers no change; but the chlorate, at a temperature much below that requisite if it be heated alone, parts with the whole of its oxygen, and becomes converted into chloride of potassium. The mode in which the oxide acts, in so remarkably increasing the rapidity with which chloride of potass can be decomposed, has been made the subject of special inquiry by Mitscherlich, and will be found discussed in the recent part of Taylor's Scientific Memoirs.*

I do not stop, however, to say any thing concerning the theory of this action. It is of more importance to substantiate the certainty and practicability of the process; and, in proof of this, it may be enough to mention, that, in the chemical laboratories of this city, and everywhere else, I suppose, where it is known, this method of preparing oxygen has supplanted every other.

For mixture with the chlorate, the black oxide of copper, obtained by calcining the nitrate of copper, or the native black oxide of manganese, is generally made use of. But they have disadvantages in reference to their employment in medical practice. The oxide of copper is too expensive, and cannot be everywhere procured. The oxide of manganese, on the other hand, is never pure, and frequently contains carbonates, which would yield their carbonic acid when heated along with the chlorate, and deteriorate the oxygen with carbonic acid—the worst possible gas that could be thrown into the lungs of an asphyxiated person. The native oxide of manganese is, therefore, quite inadmissible, unless it have been previously raised to a full red heat; and even then is objectionable, on the ground of its variable composition, and the uncertainty of procuring it everywhere, as neither it nor any of its compounds are employed in pharmacy.

I find, however, that the common red or peroxide of iron acts as well as the oxide of copper or of manganese; and, as it can be procured or prepared easily everywhere, and is

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* Vol. iv., Part 13, page 9.

cheaper than either, I recommend it for medical use. Where it cannot be obtained ready-made, it can easily be prepared by calcining the common green sulphate of iron; and it would be wise, in every case, to wash the calcined mass on a filter, and heat it a second time to redness, to secure its purity. The oxide is to be pulverized, and triturated along with five times its weight of chlorate of potass, previously reduced to fine powder. The mixture should be preserved in tightly stoppered bottles, which, as a further precaution against the entrance of dust, might be provided with caps, or tied over with leather. It is unnecessary to insist at length upon the importance of preventing dust, or any other organic combustible matter, finding its way into the mixture of oxide and chlorate. Any such substance would burn in the oxygen of the salt when the temperature rose, and not merely consume that gas to no purpose, but replace it by the highly prejudicial carbonic acid. Here, then, is a mixture which begins to part with oxygen as soon as heat is applied, and continues to give it off in an intermitting stream, till the whole is evolved. The absolute quantity which it will yield is determined by the fact, that the chlorate contains 37 per cent. of its weight of oxygen; so that 1 ounce of the salt will yield 540 cubic inches, or nearly 2 gallons of the pure gas. The temperature necessary to begin the decomposition is not high—not higher than 400°—so that within a few seconds after applying the flame of a spirit-lamp, or of a gas jet, to a glass vessel containing the mixture, the gas begins to come away.

The quantity of gas which can be procured within a given time is the point of greatest importance in reference to its medical application, and this will depend entirely upon the amount of material heated at once. The practical question, therefore, is, can a sufficient amount of the mixed chlorate and oxide be conveniently heated at a single time, to supply oxygen in the quantity requisite for its effectual application to the maintenance of artificial respiration? The quantity of air taken in at each ordinary respiration, by an adult, is 22 cubic inches, and 16 or 17 such respirations occur each minute. In maintaining artificial respiration, however, it is not possible to inflate the lungs more frequently than 10 or 12 times in a minute, nor is it considered advisable to intro-

duce more than about 15 cubic inches of gas each time. Let us take the highest estimate, however, and suppose 22 cubic inches of oxygen consumed at each inflation. This repeated 12 times would amount to 264 cubic inches per minute.

Two retorts of 12 oz. liquid capacity, heated by argand or rose burners, would suffice to obtain the gas at this rate. Should it be thought desirable to have it supplied in larger quantity, it would only be necessary to enlarge the containing vessel, which, in no supposable case, need be of formidable dimensions. The retorts, with a view to convenience and economy, might be constructed of sheet brass or iron, and could be heated by gas burners in the ordinary way, by gas burned above wire gauze, or by placing them at some little distance over a common fire. In every case, it would be desirable to have at least two similar generators, so that when the contents of the one were exhausted, the other might immediately be substituted for it, while it was refilled.

The proportion of metallic oxide recommended to be added is a tenth of the weight of the chlorate; but from experiments made in my laboratory, by my assistant, Mr David Forbes, it appears that the quantity of oxide may be advantageously increased, and that the chlorate yields its oxygen most freely when mixed with a fourth or fifth of its weight of the oxide.

Although the metallic oxide suffers no change, and may be used over and over again, any number of times, provided it be heated to redness, after the chloride of potassium resulting from the decomposition of the chlorate has been washed from it, its action is not so purely mechanical that it can be replaced by other inert bodies. Neither sand nor clay, in a state of coarse or fine division, has any effect in increasing the evolution of oxygen from the chlorate, which is so far to be regretted, as their cheapness and abundance would have made them preferable to the rarer and more expensive oxides; but, after all, oxide of iron is not very costly.

So far as the expense of the materials is concerned, it would present no serious objection to the employment of the gas. The original outlay for gas-holders and other appara-

tus, might be about L.5 or L.10; chlorate of potass, in consequence of its large consumption in the preparation of lucifer matches, can now be obtained for 6d. an ounce retail, or 4d. wholesale, and an ounce will yield, as we have seen, 540 cubic inches of oxygen. I suppose none of our benevolent institutions would think a man's life purchased too expensively, at the cost of even many ounces of the chlorate at that rate. There is every reason, however, to expect that the chlorate will soon be cheaper, as a method of preparing it from bleaching powder has been recently recommended anew to the attention of manufacturers, as supplying it quite pure, at a lower rate than the old process.

A more important question, however, remains. Does the process we have been considering supply oxygen in a state of purity? and the answer must be, Not in a state of absolute purity. When the mixture of chlorate and metallic oxide is heated it fuses, and the gas comes away quite colourless and pure; but towards the end of the process, the evolution of gas, which has always been swift, becomes suddenly more rapid, so as even to blow out the corks or stoppers of the flasks or retorts in which the mixture is heated, unless a free passage be given to it. At the same time the mixture rises spontaneously to a red heat, even though the light below it may have been withdrawn for half a minute, and white fumes accompany the oxygen. These fumes I have found to consist of chloride of potassium, which appears to be partly sublimed when the mixture rises to a red heat, partly to be carried over mechanically in the rush of gas. A little free chlorine at the same time shews itself, and to judge from the odour, a little chlorous acid ($Cl. O^4$) also. But both are in very small quantity. The oxygen containing these impurities, is not in the least injured by their presence, in so far as its power of supporting combustion is concerned. Its action on combustibles is that of the purest oxygen. And as the impurities referred to are all quite soluble in water, they are speedily removed by that liquid, if the gas is left standing over it for a short time. Their amount, moreover, is so slight, that I question if they would inconvenience any one breathing the gas contaminated by them. I have frequently inhaled

the unpurified gas myself, and have found that it had a faint aromatic flavour like that of chlorous acid, and that it did not excite cough or any sense of irritation; and as my lungs are irritable, from repeated attacks of bronchitis, the trial, I believe, was a fair one.

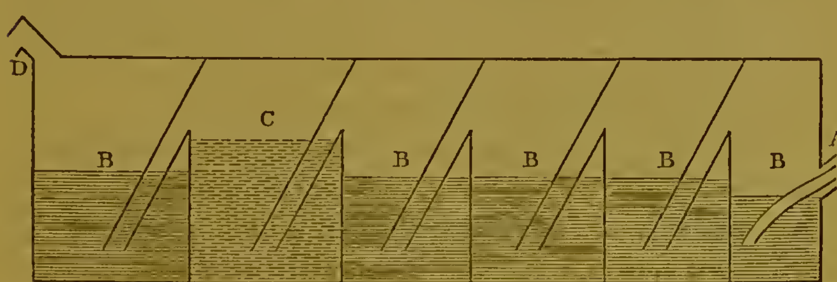
Nevertheless, there can be but one opinion, as to the desirableness of ridding the gas of even the slightest impurity, before throwing it into the lungs of an asphyxiated person. And I find that this may be easily effected, by passing the gas through a tube containing a mixture of slaked lime and sulphate of soda, which absorbs the chlorine, chlorous acid, and any carbonic acid which may have resulted from the presence of organic matter, in the mixture of chlorate and oxide, while at the same time it arrests the chloride of potassium. The lime is the efficacious absorbent in the mixture referred to, but the presence of sulphate of soda, as Professor Graham has shewn, brings the former into the most favourable condition for absorbing gases.

In employing this mixture to purify the oxygen, I found that the obstacle it opposed to the passage of the gas, when placed between the retort containing the chlorate and metallic oxide, and the gas-holder, was such as frequently to lead to the blowing out of the stoppers, and to endanger the whole apparatus. I prefer now, accordingly, to permit the gas to pass directly into the gas-holder, and to interpose the purifier between it and the tube by which the oxygen is drawn off for administration to the patient.

The best form of gas-holders, I believe, would be that adopted at the gas-works, viz., a cylinder or drum of sheet metal, closed at one extremity, suspended with the mouth downwards, in a cylinder, like itself, inverted, filled with water. The drum being hung by chains passing over pulleys, and terminating in counterpoising weights, is filled with water by sinking it in the lower cylinder or well, whilst the air is permitted to escape. When oxygen or any other gas is thrown into the drum, the latter rises out of the well to a height proportionate to the quantity sent into it. One important advantage attending this form of apparatus, is, that gas can be drawn off by a properly arranged tube from the

upper part of the drum, whilst it continues to be thrown in from below. Another is, that if the well be once filled with water it needs no replenishing, the water not being displaced when the gas enters, as in the ordinary laboratory gas-holders ; so that the original supply of water will serve, except in so far as casual accidental losses are concerned, for any number of times ; or water and gas-holders may be entirely dispensed with, and large bags of waterproof (Mackintosh) cloth be made use of, as they are now employed for containing oxygen and hydrogen for the exhibition of experiments with the lime-ball-light.

The gas would require, in that case, to be passed through water to wash it, and afterwards over the mixture of lime and sulphate of soda, so as to purify it before it was collected in the bags. An arrangement like a series of Woulfe's bottles, constructed of tin, copper, or zinc, would serve very well for this purpose. Such an apparatus is figured below.




A Aperture by which the gas enters the purifier, the tube of the retort delivering the oxygen being made to dip below the surface of the water in the first chamber.

B Chambers, which may be more or fewer in number according to circumstances, containing water to wash the gas.

C Chamber containing mixture of slaked lime and powdered sulphate of soda.

D Exit tube communicating with gas-holder.

It might be advisable even to place milk of lime in the washing chambers, instead of pure water, as an additional provision towards purifying the gas.

Waterproof cloth bags are so convenient, and, if properly taken care of, also so durable, that for ordinary hospital use, where the oxygen apparatus would only occasionally be em-

ployed, and where it would be of the utmost importance that it should be readily transferable from one room to another, they would probably be preferable to any form of metallic gas-holder. But in institutions like Humane Societies' Rooms, where resuscitating processes are always carried on in the same apartment, the counterpoised gas-holder already described might be found, in the end, more lasting and convenient. It would not entail great expense if both forms of apparatus were kept ready for use.

Where it was thought advisable to use the waterproof cloth, the best form, perhaps, it could be thrown into, would be that of a cylinder, the top and bottom being made of wood, and the whole kept in a box, so as to protect the bag from injury. It would be advisable also to have a spindle or rod passing from the upper board, through an aperture in a transverse bar placed across the open mouth of the containing box, so as to guide the movements of the bag as it rose or fell when gas was entering or leaving it. The bag would rise when gas was thrown into it, and, by placing weights upon the upper board, it could be made to deliver its contents at whatever rate was deemed advisable.

The last question we proposed to consider was, How should oxygen be administered to an asphyxiated person?

Two methods are at present in use, where common air is employed for the maintenance of artificial respiration. The one consists in imitating the motions of the chest during respiration; the thorax and abdomen being alternately compressed, so as to expel the contents of the lungs, and relieved from compression, so as to permit the chest to expand and the air to enter the respiratory organs. The other method is, to introduce a tube into the mouth, nostrils, or trachea, and force in air through it by means of bellows or a syringe; the chest being, as in the other method, alternately compressed, so as to imitate the natural process of expiration. Either of these processes can, of course, be followed with oxygen as well as with air, and practical medical men must decide which of them is preferable in particular cases. On the only occasion where I witnessed a case of asphyxia since I proposed to employ oxygen, after filling two gas-

holders and conveying them some distance, it was found impossible to make use of the contents. The patient, an old man, dying of asphyxia, resulting from bronchitis, complicated with disease of heart, was not so conscious as to be induced to attempt to respire the oxygen himself, whilst he retained sensation sufficiently to resist all attempts to introduce it artificially into his lungs. For cases such as this, and perhaps also for others, even where the patient was quite insensible, and would not resist the introduction of the gas, it is necessary that some method should be substituted for its forcible insufflation. And the simplest arrangement for this purpose appears to be, to inclose the patient's head in a chamber or box supplied with oxygen, so as to oblige him, if respiring at all, to breathe that gas; and if not, to secure oxygen entering his lungs when the chest expands, after the thorax and abdomen have been forcibly compressed, and the compression thereafter removed. The box for this purpose may be made of wood or tin, or, better, of wicker work or spars, covered with waterproof cloth. It should at least be large enough to contain the head and neck of the patient, with room for free motion, to the extent of several inches, in every direction; and the front should be hinged, so that it might be thrown open at once if necessary, and glazed so as to admit light to the patient, and permit his face to be seen. The lower end or side of the box, where the patient's head was introduced, might be terminated in a cylinder or loose tube of waterproof cloth, which could be tied round the neck by a ribbon, or made to draw with strings like those of a pillowslip, or be attached to the skin by a piece of sticking-plaister, so as to prevent escape of oxygen. It would be necessary, of course, to have the means of constantly renewing the oxygen within the box, and of withdrawing the products of respiration, if the latter were going on. This could be done in several ways, but most simply perhaps by having one tube coming from a gasholder containing oxygen terminating in the box on one side, and another proceeding from its other side inserted into the lateral aperture of a pair of bellows, so that when the handles of the latter were put in motion in the ordinary way, the gas

in the box would be drawn through the bellows, and thereafter oxygen from the gas-holder unto the box, to supply its place.

I have had such an arrangement fitted up, and it appeared to answer very well. I have been somewhat particular in describing it, because I am assured by several surgeons that it would be much safer, and quite as efficacious a mode of applying oxygen or any other gas to the maintenance of artificial respiration, to oblige the patient to breathe it, whilst the natural movements were imitated, as to force it into the lungs by bellows or syringe. This method, however, would not be applicable to elderly persons, in whom the cartilages of the ribs had become rigid, or to very robust muscular men. Where it would find its limit I leave to the judgment of medical men. Those who prefer to throw the oxygen into the lungs could easily adapt the ordinary inflating apparatus to the purpose. It would only be necessary to have a flexible pipe, of convenient length and dimensions, attached at one of its extremities to the exit or delivering-tube of the gas-holder, and at the other made to screw or otherwise fit into the aperture provided for the entrance of air in the bellows to be used for inflation.

A valve in the pipe of the bellows opening outwards, would provide a complete security against any return of the oxygen, when the handles of the instrument were separated, so as to produce a vacuum within it; but it would not be absolutely necessary. Mr Erichsen recommends, in preference to bellows, a syringe capable of holding 20 cubic inches of gas, the piston-rod of which has a nut sliding on it, which can be fixed by a screw, so as to limit the descent of the piston, and thereby regulate the quantity of gas injected. This, Mr Erichsen thinks, should not exceed 15 cubic inches in a full grown adult male, and must be proportionally less in women and children.

It is always desirable that great care be taken not to throw in too large a quantity of oxygen at once; 22 cubic inches is the largest volume that should be attempted to be introduced at a single time, and this is probably too much. All writers on artificial respiration, moreover, dwell upon

the great importance of regularly compressing the chest and abdomen, after each stroke of the bellows or inflating syringe, so as to expel the contents of the lungs as completely as possible, before attempting another inflation; otherwise accumulation of gas may take place leading to most injurious distension, and even laceration of the lungs.

It has been suggested to me by a friend, that in asphyxia, gas might be artificially withdrawn from the lungs, as well as artificially introduced into them. He recommends an exhausting syringe to be employed to empty the lungs of their contents, and that oxygen should afterwards be either permitted to flow spontaneously into them, or be thrown in by a syringe or bellows; the emptying and filling being carried on alternately as in natural respiration. There can be no question that this would be the most certain way of rapidly and effectually renewing the gaseous contents of the lungs; and if we were at liberty to treat these organs as mere cavities, out of which a poisonous gas, carbonic acid, and a useless one, nitrogen, were to be extracted as rapidly as possible, and their place supplied by pure oxygen, the method proposed would take precedence of every other.

The production of a vacuum, however, within the lungs, would cause great congestion of blood within them, as soon as the circulation commenced there, and this would be very apt to be followed by inflammation or other morbid derangement of their structure or function, in the event of the patient's recovery.

I fear, therefore, that the suggestion I have referred to would at once be condemned by medical men, although this is not the first time it has been proposed, and in spite of its having been put in practice already. Nevertheless, the principle involved in it, that, namely, of seeking rather to empty than to fill the lungs artificially, is, I think, an important one; and as life, with the risk of subsequent congestion, inflammation, or other affection of the lungs, is better than no life at all, the method I have described may be considered at least in the light of a justifiable *dernier resort*, to be had recourse to in those desperate cases where safer remedies are of no avail.

I am not anxious, however, to discuss at great length the comparative value of the different methods by which oxygen may be introduced into the lungs. The special object of the present paper is to explain to those who are satisfied that oxygen would be a valuable remedy in asphyxia, in whichever of the ways referred to it was administered, a very simple way of procuring the gas, of great purity, in large quantity, and what is most important of all, very rapidly. If I can induce medical men to make trial of the new process, as a means of yielding oxygen, I have no doubt that if it shall prove useful at all, they will soon be able to decide what is the best way of administering it.

What I should propose is, that at our public hospitals, lying-in institutions, humane societies' rooms, police-office stations, and wherever else cases of asphyxia frequently come before the medical officers, the mixture of chlorate of potass and oxide of iron should be kept ready for use. Along with it there should be provided glass or metallic retorts, with suitable arrangements for heating them, and one or more gas-holders to receive the gas. With counterpoised gas-holders, kept full of water, or with waterproof bags, of the construction recommended, and the rest of the apparatus, and the mixture ready for immediate use, inflation with oxygen might be commenced within a few minutes after a case was brought in, and might be carried on for any length of time. This method of administering oxygen appears peculiarly applicable to midwifery hospital practice. The quantity required for the inflation of the lungs of a still-born infant could easily be supplied as rapidly as wanted, by even a small apparatus; and the whole arrangement for yielding oxygen could be made ready in working order as soon as labour began, so as to secure the gas being forthcoming the moment it was wanted. The method proposed would further apply to every form of asphyxia occurring in hospital practice, to cases of poisoning with opium, in that, and perhaps in private practice, and to other states of disease or injury which will at once occur to medical men.

The method proposed would also be applicable to other purposes. A French physician recently engaged to descend

in water to some depth, in a diving-bell, and remain there for several hours without renewal of the air; and various parties witnessed the feat performed by him in London.

It would be easy for any one to rival this, if provided with the mixture of chlorate and metallic oxide, a lucifer match, a small lamp, and a retort or flask, to evolve oxygen from the mixture. It would be necessary also to have the means of withdrawing the carbonic acid produced during respiration. This could easily be done, however, by having within the bell a vessel containing the mixture of sulphate of soda and lime, already referred to, which would rapidly absorb the carbonic acid generated.

Such a method of maintaining a respirable atmosphere within diving-bells is worth the attention of engineers. It might be found much more convenient than the present troublesome practice of sending air into the chambers by a forcing-pump.

The quantity of oxygen required for the purpose would, of course, be much less than when it was to be employed to recover a person from a state of asphyxia; not more, indeed, than a fifth of the amount necessary in that case would be required.

I need scarcely add, that in mining or tunnelling the same mode of renewing the oxygen might be found frequently useful.

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